Space Weather Technical Forecast

Issued on Saturday 5 October 2024 at 01:10 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Expected throughout, Chance of further R3. G1/G2 Expected, Chance G3 over UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity measured at GOES16 and 18 has been Moderate in the period, with the peak flare an M4.0 at 04/0455UTC from AR3842. Background X-ray flux has been notably high, decreasing slightly over the 24 hours from near the C/M flux boundary. Penticton 10.7cm flux decreased a little to 291sfu from a peak in the current rotation of 312sfu on 03 October. The peak for the current cycle is 336sfu on 08 August.

There are seven numbered sunspot regions on the disc at present, with a small unipolar spot fading from view in the eastern hemisphere as two further regions in the west neared the limb. The southwestern quadrant is particularly congested, with several large and complex regions occupying this part of the disc at present. The first of these, AR3842, showed several Mt Wilson delta spots, a sheared appearance in its leader and growth and movement in its trailing spots. AR3844 - to its west - was also a large delta spot-containing group, with areal growth of its penumbrae and a spreading tendency seen. Thirdly, AR3843 further west was a little more open in character, with intermediate spot emergence and a spreading trend in the past 24 hours.

The three eastern solar hemisphere regions only showed very small changes, although these were perhaps masked by the narrow viewing angle in AR3849 in particular. In the western hemisphere, AR3841 showed late proliferation of its intermediate spots, but was otherwise unchanged, while AR3839 was unchanged as an Hsx group in the south.

AR3842 and AR3844 have several small filaments strung through their constituent sunspots - something to monitor given their tendencies towards occasional large flares. Some instability was observed in filaments in the south-central and far southwest quadrant into the UTC evening of 04 October, although no Coronal Mass Ejections (CMEs) have been associated with these at the time of writing. Instead, the up to three CMEs seen heading southeast in Lasco C2/3 imagery through the UTC day are thought to be associated with a narrowly far-sided southwestern activity to no effect at Earth. A northeast-heading event on the same coronagraphs in the UTC evening was also thought far-sided.

No new Earth-directed CMEs were therefore in evidence.

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Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE at L1 was indicative of a slow regime.

The solar wind speed showed a very slight rising trend through the upper 300s of km/s to peak near 400km/s. The solar wind density was level within single figures ppcc. The IMF was also level, with a Slightly Elevated peak of 9nT and an erratic north-south component ranging between +/-7nT. The phi angle was negative (towards the Sun) throughout.

The net effect of the above solar wind measures was for provisionally Quiet to Unsettled geomagnetic indices, peaking with a Kp '3+' in the 21-24UTC interval.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background to Moderate levels (at diurnal peak), with a peak value of 160pfu at 04/1530 UTC. The associated 24-hour fluence was below the Active threshold, falling through the period to 4.25e6 observed at 04/2359UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Expected to be Moderate, with a Chance of returning to High should another isolated X-class flare occur, these most likely originating from AR3842 or AR4844. Recurrence does not suggest any returning large regions in the forecast period, and both the major sunspot regions on the facing side are present throughout - the significant flare risk is therefore largely constant.

Solar Wind / Geomagnetic Activity: There are two main CMEs due in the period: firstly a glancing blow from the X7.1 flare CME into day one, Saturday 05 October. Secondly and more assuredly, the arrival of a CME from the 03 Oct X9.0 flare should arrive late on day one, or else early on (day two) Sunday 06 October.

Confidence is low into the new UTC working week, however any further CME glances are expected to be slight. G1-G2/Minor-Moderate Geomagnetic Storm periods are Expected over the current UTC weekend. Depending on how distinct the inbound CMEs are, and how much the first (lower confidence event) primes the Earth's magnetosphere, there may be a Chance of G3/Strong geomagnetic storm conditions and even a Slight Chance of isolated G4/Severe intervals.

The fast wind from CH78/+ is perhaps then due later on day four, Tuesday 08 October, potentially bringing Elevated solar winds near 550km/s and a Slight Chance of G1.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is forecast to persist at Background, with a daily Chance of rising to S1 should further significant flares occur.

High energy electron flux at GOES16 is expected to soon be further suppressed at GEO due to inbound CMEs, with a limited window for recovery before any fast wind from CH78/+ arrives

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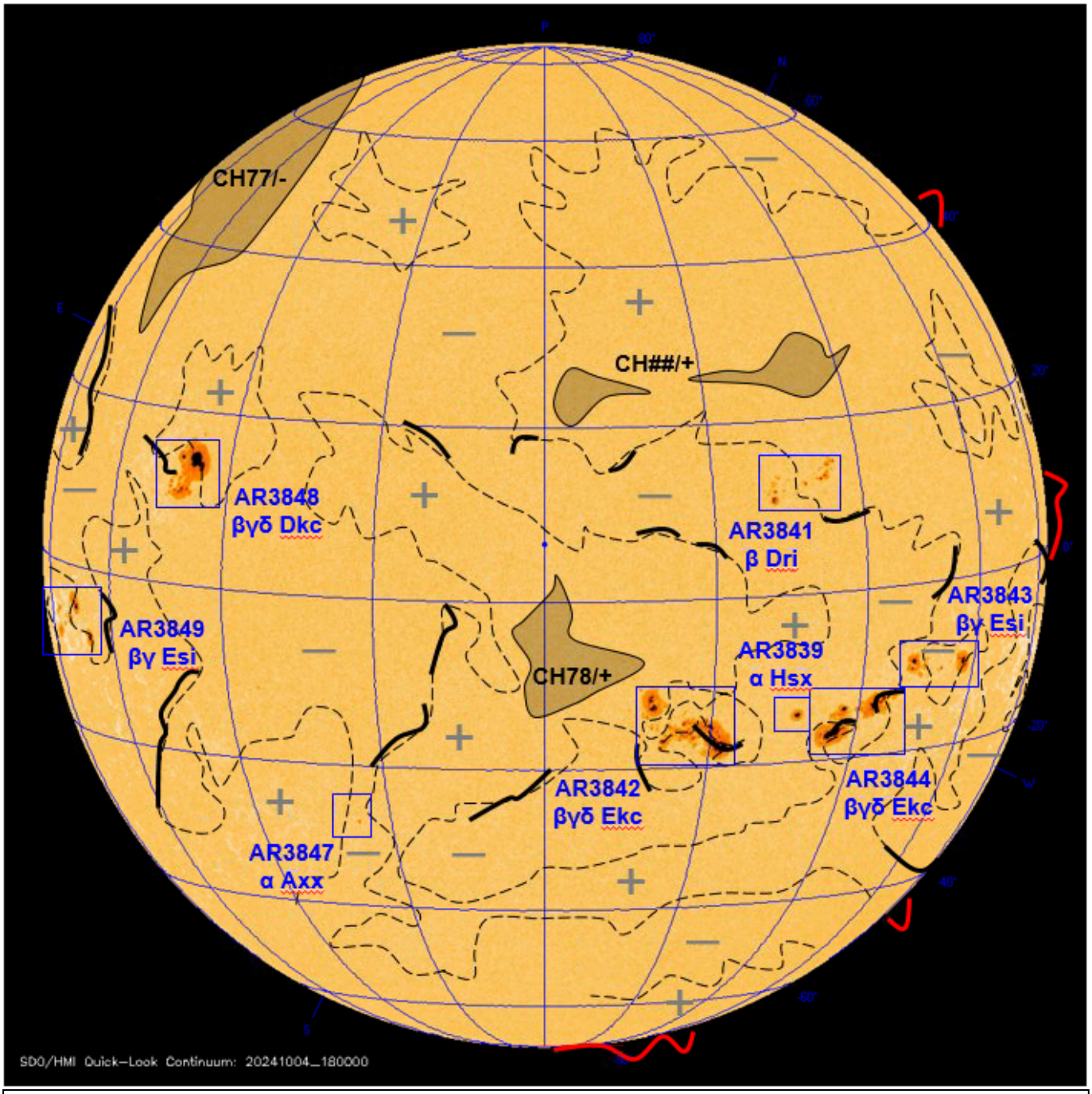
before midweek. There is a slightly rising Slight Chance of Active fluence in the four days, with low confidence overall given the predominance of early CME activity.

Figure 1: Solar synoptic map, valid 04/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There are two main CMEs due in the forecast, and perhaps a fast wind.

The CMEs comprise, firstly: a glancing blow from the X7.1 flare CME originating on 01 Oct into day one (Saturday 05 October) with the bulk of the CME expected to pass to the south of Earth. Secondly - and perhaps more significantly - the arrival of a CME from the 03 Oct X9.0 flare, with a more direct hit expected to arrive - either late on Saturday 05 October (day one) or early on Sunday. A subsequent series of CMEs pre-dating 04 October show potential glancing incidence in some Enlil ensemble members later in the forecast period, whereupon a minor fast wind from CH78/+ may also become geoeffective.

STEREO A is currently sitting at 0.96AU, although the satellite is also now 25 degrees ahead of Earth - limiting any precursor signal for any CMEs other than those emanating from the western solar hemisphere. ACE EPAM LEMS has shown a rise across the low energy proton spectrum late in the UTC evening of 04 October - this is perhaps the inbound X7.1 CME which may be imminent.

The sole fast wind due in the period is likely to be the more minor component of the forecast (versus the CMEs). This takes the form of CH78/+, which is similarly-placed but more intense in appearance than on last pass on 07 September. This rounds out the forecast period with perhaps a late Slight Chance of G1 in Elevated winds near 550km/s on day four, Tuesday 08 October.

G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) periods are Expected over the current UTC weekend, due to the forecast arrivals of the X7.1 CME and then the X9.0 CME. Depending on how distinct these two events are and how much the first (lower confidence event) primes the magnetosphere, there may be a Chance of G3/Strong Geomagnetic Storm (Kp 7) conditions and even a Slight Chance of isolated G4 (Kp 8) intervals. These larger-scale effects are perhaps most likely to straddle the intervening UTC night between the two weekend days and will rely on large, closely-spaced arrivals. Geomagnetic activity should then wane into the new UTC working week, with further CMEs perhaps glances at best, while the fast wind component of the forecast is expected to be relatively minor in comparison.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	80	80	60	10
Strong	**G3**	No	50	50	5	1
Severe	**G4**	No	20	20	1	1
Extreme	**G5**	No	5	5	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
02/0938	Partial	AR3842	SE	800	Imminent (from ACE EPAM LEMS evidence)	Low confidence based on estimates. +/- 12hrs arrival time.
03/1637	Full	AR3842	SW	882	05/1800 UTC	High confidence for being Earth directed, lower confidence arrival time.

Figure 2: Clockwise from left: AIA211 imagery from 07 September and 04 October comparing coronal hole appearances this rotation and last. Solar wind speeds at L1, showing eventual increase on the equivalent of Tuesday 08 October, along with resultant BGS Kp indices peaking at Kp3. Given the slightly intensified appearance of CH78/+ on this rotation, slightly greater geomagnetic activity is expected.

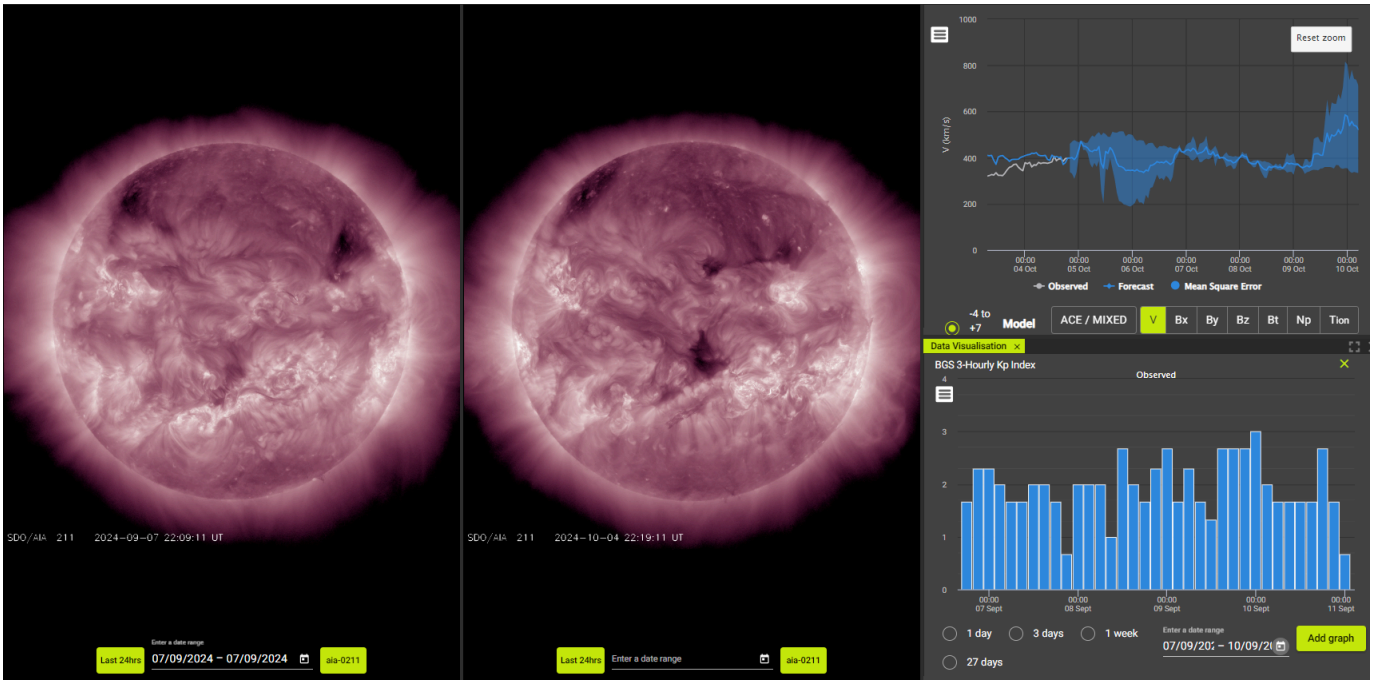

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Figure 3: Latest MOSWOC Enlil run and ensemble (badge time 04/1800UTC) showing a series of inbound CMEs. Most notably, these include the imminent X7.1 CME into the UTC weekend. The simulation is paused on the most significant of these, the X9.0 CME due between the two UTC weekend days. Some ensemble members then hint at narrow glances from further CMEs, however the deterministic forecast is for a gradual lapse towards quiet conditions, perhaps enhanced at the very end of the forecast period by CH78/+ (not shown in Enlil).

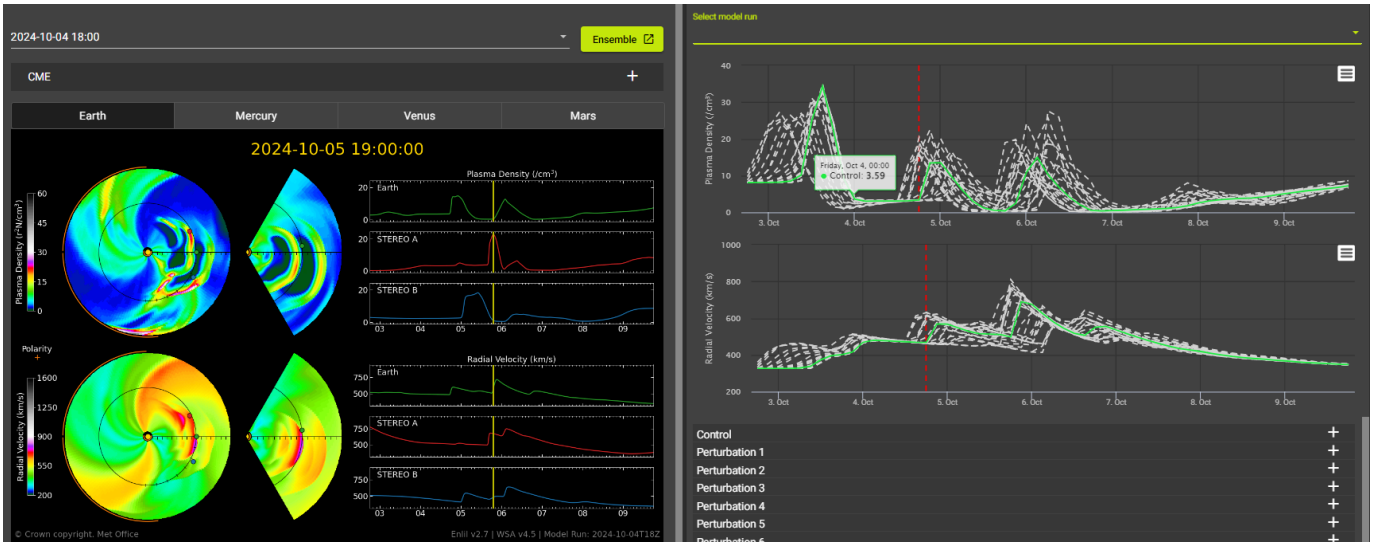

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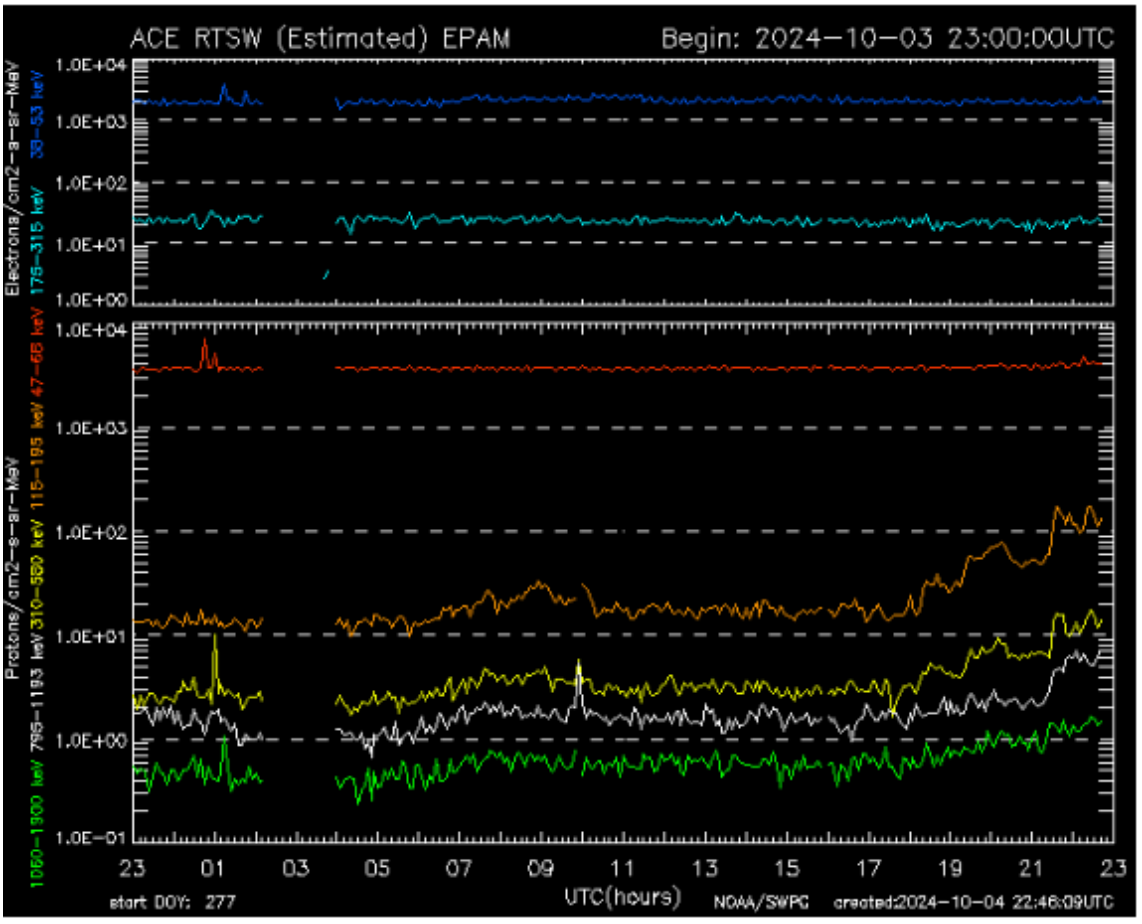
Figure 4: ACE EPAM LEMS trace to 04/2250UTC hinting at an inbound enhancement, perhaps the X7.1 CME due imminently.



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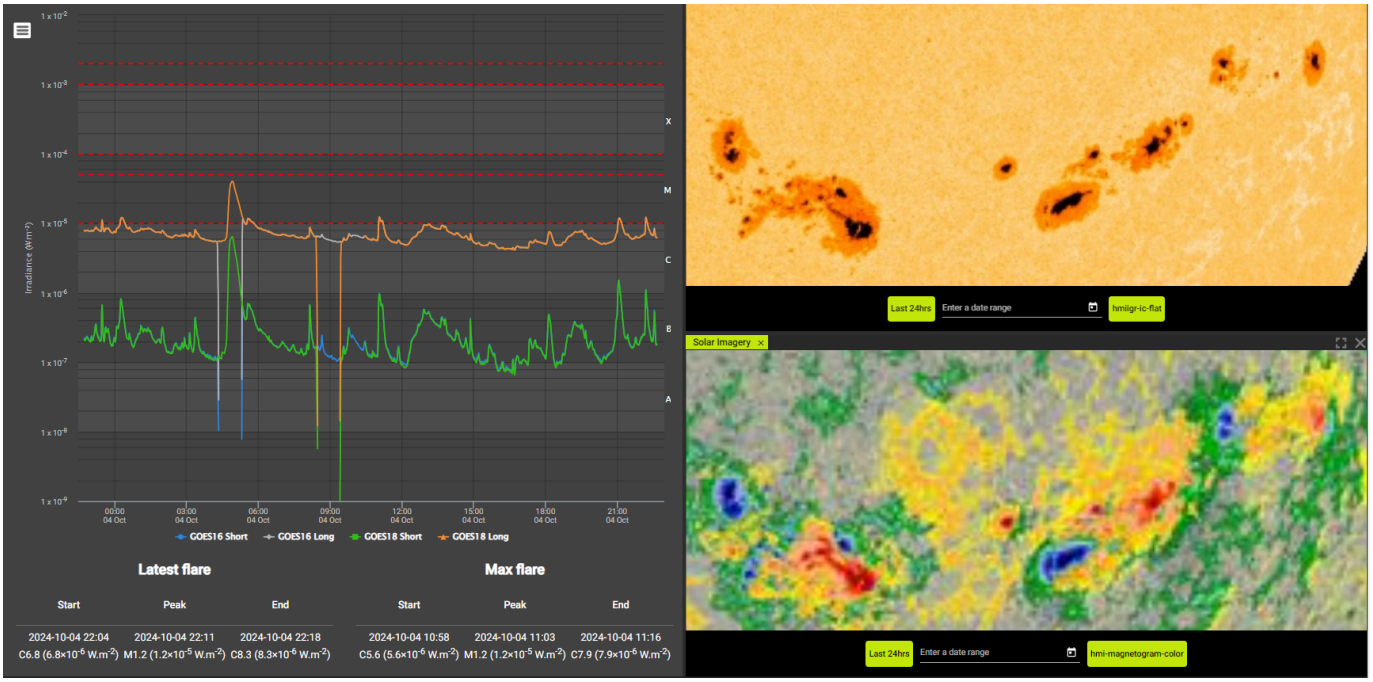
Radio Blackouts - X-Ray Flares

Far side helioseismographs and returning Carringtons due in the period suggest that there are no inbound complex regions in the four days. The disc should also retain both the major contributors to the daily risks at present - in the forms of AR3842 and AR3844, and the forecast trend is therefore largely constant, only reducing slightly on day four (Tuesday 08 October) due to the departure of AR3843.

X-Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 (M Class)	Yes	85	85	85	80
Very Active	R3-R5 (X Class)	No	30	30	30	25

Figure 5: Clockwise from left: GOES16 and 18 X-ray flux; HMIIF imagery at 04/2230UTC showing AR3842, AR3839, AR3844 and AR3843, with equivalent HMIBC shown below. Note especially the large Mt Wilson delta spot in the leading portion of AR3842.



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Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 has thus far failed to respond to any of the recent large flares, however this still becomes more likely with the sunspots' western advance. So, while modulated versus raw probabilities for the current disc, there remains a daily Chance of S1+, mainly from AR3842 or AR3844.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	25	25	25	25
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background to Moderate levels. The inbound CMEs are likely to cause flux at GEO to reduce in the near-term, and the extent of any recovery before the onset of the sole fast wind the period on day four, Tuesday 08 October is also low confidence. Overall, there is perhaps a Slight Chance of this window being large enough to allow for a brief period of Active 24-hour integrated fluence - before again being attenuated. Any lasting recovery will probably therefore not come until later in the coming UTC working week.

MOSWOC REFM is not likely to offer a useful steer as to electron populations given the dominance of CMEs in the forecast.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	1	1	10	10
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

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